

ScienceNews

IN HIGH SCHOOLS | EDUCATOR GUIDE



The Beneficial Bean



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About the article

The *Science News* magazine feature article “The Beneficial Bean” explores the numerous health benefits of coffee. Despite being a beverage that has long been seen as a vice, coffee has been shown in many research studies to have properties that help prevent fibrosis of the liver, cancer, Alzheimer’s and other diseases. The effects are so impressive that some doctors have even started prescribing the drink to patients. While the benefits of drinking coffee are now becoming clear, scientists are still working to understand exactly how this powerful bean bestows its benefits.

“The Beneficial Bean” can be used across a wide range of curricula, including chemistry, organic chemistry, biology, biochemistry, anatomy and nutrition. The activities, questions and discussion in this teacher’s guide can be used to support the following NGSS curriculum and Common Core standards:

Next Generation Science	Common Core
HS-ETS1-1	RI.1
HS-ETS1-2	RI.2
HS-LS1-3	RI.3
MS-PS1-1	RI.4
	RI.5
	RI.6
	RI.7
	RI.8

Prior to reading

Guide student reading by first outlining a theme. Point out connections between this article and what students are learning in class. Here, find ideas for a few standard-aligned paths to follow while reading:

- Explain that the focus of the article, “The Beneficial Bean,” is exploring new evidence for the positive effects that drinking coffee has on our health. With that in mind, ask students to share what they think about coffee’s benefits or possible health risks.
- Have students fill in the provided [K-W-H-L chart](#) before, during and after reading. After students fill out the “Know” section of the charts, discuss what they have heard about the effects of coffee. Ask the students about their personal experiences with drinking coffee (or other caffeinated beverages) and the physical effects that they have experienced.
- Why might there be some concerns about the health effects of drinking coffee? *(Some answers might include: addictive qualities, effect on nervous system, blood pressure increase over short-term, heart rate increase, heart-burn, interference with sleep.)*
- As you read, make notes about coffee’s effects on the body according to the studies highlighted in the article.

After reading: Comprehension

You can adapt and print this assessment (see [Blackline Master #1](#)) to check for comprehension before or after discussion.

1. In no more than two sentences, summarize the central ideas of the article.
2. What negative effects on health has coffee been linked to previously? Which of these claims have been refuted?
3. According to the article, what is the role of the liver?
4. What are the three most common causes of liver damage in humans?
5. Describe the two ways that coffee might prevent liver damage. Incorporate an illustration of these processes as well.
6. Why might a doctor of a patient with fatty liver disease suggest the patient drink coffee and why wouldn’t other caffeinated drinks (energy drinks, soda, etc.) provide the same benefit?
7. How did the scientists use rats to test their hypothesis that coffee helps prevent the onset of type 2 diabetes?

8. Explain how the section titled “The Diabetes Defense” contributes to the author’s explanation of the health benefits of coffee.
9. How would adding sugar and milk to coffee detract from coffee’s health benefits?
10. According to the article, how do the type of coffee bean and its roast as well as different brewing methods affect coffee’s potential health benefits?
11. What are two ways that the coffee components called diterpenes help to fight against cancer?
12. What are two specific health benefits of chlorogenic acids and caffeic acid according to recent studies?
13. Which of the following best describes the overall tone of the article?
 - a. Informal
 - b. Serious
 - c. Optimistic
 - d. Skeptical

Analyze

Offer students other ways to explore the content of the article, as it ties to your curriculum, such as:

1. The author points out one critic’s concern about the research that shows no link between coffee drinking and atrial fibrillation. He states that, “People who get symptoms from coffee tend to stop drinking it. So the only coffee drinkers in some studies would be those who don’t feel any bad effects, a self-selecting group.” Explain this critique.
2. Working in small groups, choose 2 to 4 of the studies mentioned in this article that you find to have weaknesses or whose findings you doubt. Explain which studies you chose and why you chose them.

Extend

- In the section, “Beyond the Liver,” the author discusses the different types of cancers that coffee might help protect against. He then offers several candidates as a biological explanation for these effects, including:

- Polyphenols boosting DNA repair genes
- Chlorogenic and caffeic acids’ demethylation abilities
- Diterpenes suppressing angiogenesis (blood vessel growth that tumors need)

Choose one of the above topics (DNA repair genes, methylation/demethylation, or angiogenesis) and then research and describe how that process may play a role in the development of cancer.

- Due to the popularity of Starbucks and other coffee shops, coffee drinks are often served containing sweeteners, syrups, flavors and dairy products. There has been much research and attention about the harmful effects of “sugary” drinks to the point where some localities have attempted to limit their consumption.

Find a study or article to present to the class that discusses the health risks associated with these high-sugar drinks and lead a discussion about how this would offset the benefits of coffee as presented in this article.

- **Isolating Caffeine.** This experiment is easily done in a high school chemistry setting. [See appendix 1.](#)



The Beneficial Bean

Reading Strategy — K-W-H-L Chart

Students can use this chart to help them comprehend the topics from the article, “The Beneficial Bean.” Note that the ‘H’ column encourages students to think about information sources besides the article they can use to answer their questions.

K What I know	W What I want to know	H How I'll learn it	L What I learned

Reading Comprehension

After reading the article, “The Beneficial Bean,” answer these questions:

1. In no more than two sentences, summarize the central ideas of the article.
2. What negative effects on health has coffee been linked to previously? Which of these claims have been refuted?
3. According to the article, what is the role of the liver?
4. What are the three most common causes of liver damage in humans?
5. Describe the two ways that coffee might prevent liver damage. How would you go about illustrating this?

6. Why might a doctor of a patient with fatty liver disease suggest the patient drink coffee and why wouldn't other caffeinated drinks (energy drinks, soda, etc.) provide the same benefit?
7. How did the scientists use rats to test their hypothesis that coffee helps prevent the onset of type 2 diabetes?
8. Explain how the section titled "The Diabetes Defense" contributes to the author's explanation of the health benefits of coffee.
9. How would adding sugar and milk to coffee detract from coffee's health benefits?
10. According to the article, how do the type of coffee bean and its roast as well as different brewing methods affect coffee's potential health benefits?
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12. What are two specific health benefits of chlorogenic acids and caffeic acid according to recent studies?

13. Which of the following best describes the overall tone of the article?

- a. Informal
- b. Serious
- c. Optimistic
- d. Skeptical

Analyze

Use what you already know about the topic, as well as what you learned in the article "The Beneficial Bean," and answer these questions:

1. The author points out one critic's concern about the research that shows no link between coffee drinking and atrial fibrillation. He states that, "People who get symptoms from coffee tend to stop drinking it. So the only coffee drinkers in some studies would be those who don't feel any bad effects, a self-selecting group." Explain this critique.

2. Working in small groups, choose 2 to 4 of the studies mentioned in this article that you find to have weaknesses or whose findings you doubt. Explain which studies you chose and why you chose them.

Experiment — Isolation of Caffeine from Mountain Dew

The soft drink Mountain Dew is a mixed solution of several compounds in water, including carbon dioxide, food coloring and the common stimulant caffeine. The combination of caffeine, sugar and carbonation give the beverage its “kick,” making it a popular drink. Our goal in this experiment will be to extract the caffeine, separating it from the remainder of the soft drink solution. Caffeine cannot be separated from Mountain Dew by the simple separation methods such as evaporation and filtration. Instead, it must be chemically extracted from the solution. Students will treat the soda with methylene chloride (CH_2Cl_2), an organic chemical that does not mix with water. While caffeine dissolves in water, caffeine is even more soluble in methylene chloride, a solvent. Swirling the mix will encourage the caffeine to migrate to the methylene chloride, leaving the other dissolved compounds in the water. Separating the organic layer from the water layer and evaporating the solvent yields solid crystals of caffeine.

Materials Required

- Cans of Mountain Dew (1 can for every 3 students)
- Methylene Chloride (about 25 mL per student) in 3 or 4 bottles, no droppers attached
- 4 small containers of Na_2CO_3 (about 2 grams/student)
- 4 small containers of NaCl (table salt, not Rock Salt) (about 2 grams/student)
- Clay triangles (1 per student)
- Small waste container in hood labeled as “Halogenated Organic Waste” for leftover CH_2Cl_2

ALSO: Please place 3-4 hot plates in the hoods. Turn them on to a low-medium setting before the class begins.

1. Obtain a can of Mountain Dew (opened or unopened). Measure 75 mL of the soda in your large graduated cylinder. Give the remaining soda to another student. Also, check to make sure that your 50 mL beaker is completely dry. If not, use paper towels to remove any water and allow it to air dry completely. You will not need it until step 10.
2. Pour the soda from your graduated cylinder into your 250 mL Erlenmeyer flask. Swirl and shake the flask for about 5 minutes, until foaming is significantly reduced. Do this over a sink and try not to spill any!
3. Use the electronic balances to measure out approximately 1.5 grams of sodium carbonate (Na_2CO_3) onto a piece of weighing paper. Then add it to your 250 mL Erlenmeyer flask. Swirl the soda mixture until the sodium carbonate dissolves.
4. Pour 20 mL of methylene chloride into a graduated cylinder. *Caution: Methylene chloride is a suspected carcinogen. Wash your skin immediately if any should splash on you. Unlike most organic solvents, methylene chloride is not flammable.*
5. Pour the methylene chloride into your 250 mL flask. The liquids in the flask should separate into two distinct layers, with the more dense methylene chloride on the bottom. Swirl the flask for about 10 minutes to thoroughly mix the liquids. Do not shake or you may form an emulsion which is difficult to remove at a later stage.
6. Set the flask aside and allow it to sit for about 10 minutes. In the meantime, prepare a gravity filtration set-up as follows:
 - a. Place an iron ring on a ring stand. The ring should be about 8 inches above the bottom of the stand.
 - b. From the cart, obtain a clay triangle. Place the triangle on the iron ring.
 - c. Insert the stem of your funnel through the clay triangle. Place a 250 mL beaker below the stem. This beaker does not need to be dry.
 - d. Obtain a piece of filter paper. Fold it into quarters, then open it into a cone (your instructor will show you how to do this) and place it into the funnel.
 - e. Use your wash bottle to thoroughly wet the filter paper with distilled water. The paper should cling to the side of the funnel. This step is essential for success!
7. If an emulsion (a thick layer of small bubbles) has formed in the flask, carry out the following steps. Otherwise, skip to **step 8**. Add about 1 gram of sodium chloride to the flask (NaCl), swirl for about 2 minutes, and let the flask sit for another 5 minutes. Repeat this process a second time if necessary. It is OK to proceed even if the emulsion has not completely broken up.
8. Carefully try to separate the two layers by pouring only the top layer into a large beaker (any beaker will do, except for your 50 mL beaker). It is important that the bottom layer remain in the Erlenmeyer flask. It is alright if a small amount of the top layer remains in the Erlenmeyer flask as it will be removed in the next step.

9. Gently pour the liquid remaining in the Erlenmeyer flask into the filter you setup in step 6. Any remaining water should migrate to the filter paper and separate from the methylene chloride. However, the methylene chloride should not pass through the wet filter paper. You may need to carefully stir the liquid in the filter with your stirring rod to help separate any water trapped in the methylene chloride.
10. Write your initials on your dry 50 mL beaker, and weigh it on the balance. Record the mass on your report sheet.
11. Using your dropper, transfer the methylene chloride solution remaining in the filter cone to the 50 mL beaker. Leave behind any emulsified portions which did not separate.
12. Set the beaker on a warm hot plate in a fume hood to evaporate the methylene chloride. The hot plate should be at a low-to-middle setting. Keep your eye on the beaker, especially after more than half of the solvent has evaporated. .
13. Once all the solvent has been evaporated, you should immediately remove the beaker from the hot plate. It should not be too hot for you to pick up with your fingers. The beaker should contain a residue of caffeine powder. Do not allow the beaker to sit too long or some of your caffeine may sublime.
14. Allow the beaker to cool for about 3 minutes. Then, weigh the beaker on the same balance you used in step 10. Record the mass on the report sheet.
15. Have your instructor take a look at the crystals in your beaker and initial your report sheet. Then, clean up your lab area. Any leftover solution (such as those collected in steps 8 and 9) are mostly water and should go down the drain. The caffeine may also be washed down the drain. Any leftover methylene chloride (if you took too much in step 4) should go in a waste container in the hood marked "halogenated organic waste."

Experiment Report Sheet— Isolation of Caffeine from Mountain Dew

Volume of your Mountain Dew sample: _____ mL

Mass of dry 50 mL beaker: _____ g

Mass of 50 mL beaker + caffeine residue: _____ g

Mass of caffeine residue: _____ g

Divide the mass of the caffeine residue by
1,000 to convert to milligrams of caffeine: _____ mg

Total volume of soda in a 12 oz. can
in milliliters (read off the can): _____ mL

Determine the number of milligrams of caffeine in one can of Mountain Dew.
To do this, set-up the ratio below and solve for x. Show your calculation.

_____ mg caffeine/can

Instructor's Initials: _____

Experiment Questions — Isolation of Caffeine from Mountain Dew

1. Pure caffeine is a white, powdery solid. Based on this information, how pure would you say your sample is?
2. The caffeine collected in this experiment is often not white. What is the source of the impurity that gives the impure caffeine its color?
3. In step 13, you were warned not to overheat your sample on the hot plate. What does the term sublimate mean in this instruction?
4. It is possible to purify the caffeine by sublimation. Write down a short procedure demonstrating how this could be accomplished. Hint: Research the procedure for subliming iodine.